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# Connection Device for a Control Lever and a Support Element of a Valve Controller of an Internal Combustion Engine

## Field of the Invention

The invention relates to a connection device for the pivotable and captive connection of a control lever and a support element of a mechanical valve controller of an internal combustion engine.

## Background of the Invention

From DE 196 17 523 A1, a connection device is known, wherein such a control lever and a support element associated with it are connected via a retaining element in a pivotable and captive manner. This connection device is especially advantageous because it makes it possible to avoid assembly problems in the manufacture of a mechanical valve controller of an internal combustion engine.

The retaining element known from this publication is designed as a sheet-metal bracket, wire retaining clamp or plastic retaining cap, which engages into, among other things, an undercut in the support element below the spherical end of said support element. In the version of the sheet-metal retaining bracket, to be explained in more detail in the following, this retaining element possesses an essentially U-shaped cross-sectional geometry and comprises two legs that are connected to each other via a connecting section. The first, closed-surfaced leg is attached to the cam follower above a receiving calotte, while the second, bifurcated leg engages into the undercut of the support element projecting into the calotte. Furthermore, both legs exhibit, on their free ends, retaining collars, with which the retaining element may be clamped onto the cam follower as well as the support element in a captive manner.

Although this known connection device has a number of advantages, the fact that respectively adapted retaining elements are needed for different cam follower geometries still has to be considered as disadvantageous.

US 6,047,675 B2 and US 6,543,402 B2, respectively, also disclosed another valve controller for an internal combustion engine, with these valve controllers also using wire-shaped retaining elements or retaining elements designed as sheet-metal parts for the purpose of connecting the cam follower and the support element. The sheet-metal retaining clamp is U-shaped in this case as well, with the two parallel running sheet-metal legs being connected to each other via a connecting section.

Furthermore, contrary to DE 196 17 523 A1, the two legs exhibit circular or U-shaped receiving openings in the area of their free ends. While the lower leg of this retaining element engages at the support element, the upper leg envelops, with its receiving opening, a portion of the spherical top side of that receiving calotte in which the also spherically shaped top side of the support element is supported in terms of a ball bearing.

Of special significance for the sheet-metal retaining clamp with the geometrically closed openings in the legs is the fact that respective protrusions project into these receiving openings, with said protrusions resting with friction fit against the undercut-less cylindrical portion of the support element and holding it in a gripper-like manner, or being pressed onto the spherical top side of the support element.

It is considered to be a disadvantage of this connection device that the support element is held only in a gripper-like manner and by friction fit by the sheet-metal retaining clamp. Since there is no provision made for an engagement into an undercut (which does not exist in this case) of the support element, it has to be anticipated that the cam follower and the support element will fall apart in the event of heavy mechanical stress.

## Summary of the Invention

Against this background, the invention is based on the technical problem of creating a connection device for a connection between a cam follower and a support element, with said connection device being suited for different cam follower geometries in the connection area with the support element. Furthermore, this connection device is to ensure a secure, articulated and captive connection between the cam follower and the support element even in the event of heavy mechanical stresses. And, finally, the retaining element of the connection device, which implements the mechanical connection between these two components, is to exhibit a low tendency to get stuck when stored with other retaining elements in a container, is to be capable of being automatically mounted and is to be capable of being manufactured at low cost.

The solution to this problem is based on the features of Claim 1, while the advantageous further developments and embodiments of the invention are revealed by the subclaims.

Accordingly, the invention relates to a connection device for the pivotable and captive connection of a control lever and an associated support element of a valve controller of an internal combustion engine, wherein the control lever exhibits, in one supporting section, a calotte-shaped recess in which the spherical end of the support element is located; with the connection device having an undercut below its spherical end in the support element; and with the control lever in the supporting section above the calotte-shaped recess exhibiting a spherical geometry; and wherein a retaining element connects the control lever and the support element.

It is also provided that the retaining element exhibits a U-shaped cross-sectional geometry, with an upper and a lower leg being connected via a connecting section.

There are also geometrically closed openings provided in the legs for the purpose of receiving the undercut of the support element or the spherical top side of the supporting section of the control lever, with the opening in the upper leg being essentially round and the opening in the lower leg being essentially slot-shaped.

In embodiments of the invention it is possible to design the control lever as a cam follower and the support element as an axially movable piston.

With respect to the retaining element, it is considered advantageous for its material thickness to be less than the width of the undercut so that it is freely movable in all pivot positions of the control lever in the undercut.

According to another embodiment of the retaining element, the legs and specifically the connecting section of the retaining element are smooth-surfaced, reducing the tendency toward jamming of such a retaining element in an assembly supply container and allowing easy placement onto the control lever and the support element. It is specifically the closed surface of the connecting section that allows this component part to be grasped with an automatic assembly vacuum gripper.

In particular, the placement of the retaining element onto the control lever between its side walls is facilitated if the legs of the retaining element exhibit lead-in chamfers in the area of their free ends, virtually sharpening these legs.

Another facilitation of assembly in putting together the control lever and the support element can be achieved in further developments of the invention by designing the free ends of the legs such that they point away from each other.

In the further development of the invention, the positioning of the retaining element on the support element is also benefited by the slot-shaped opening in the lower leg exhibiting a stadium-like geometry, with two opening sections, running parallel to each other, being connected by semi-circular opening sections.

The expansion of this opening in the lower leg, which is required for the placement of the retaining element onto the support element, is further facilitated if a slot-type extension of the opening with a preferably small opening width is provided in at least one of the above-mentioned semi-circular opening sections. This makes it easier for the sections of the lower leg to twist against each other during the axial placement onto the support element, causing the cross section of the opening to be briefly expanded. Following the above-mentioned placement, the originally smooth surface of the lower leg is reconverted so that this leg then engages into the undercut of the support element in a captive manner.

Furthermore, the opening in the upper leg of the retaining element is designed such that this leg is securely fastened on the spherical, e.g. ball-shaped head-type top side of the supporting section of the control lever.

In accordance with another further development of the invention, it is provided that the width of the opening in the lower leg is smaller across its longitudinal extension than the diameter of the opening of the upper leg. The effect of this combination is that, given a preset undercut depth, sufficient retention is ensured on the spherical top side of the control lever, or that, given a preset diameter of the opening in the upper leg, a sufficiently large undercut depth is utilizable. To ensure a secure retention, it is essential that the width of the opening in the lower leg at a right angle relative to its longitudinal extension is smaller than the diameter of the support element above and below the undercut.

Furthermore, the design of this retaining element can also be such that the upper leg is axially shorter than the lower leg. This advantageously achieves a reduction of weight and costs as compared to legs of equal length, while the secure retention on the spherical top side of the supporting section of the control lever is ensured even when the retention element does not precisely envelop, with the opening of its top legs, the pole area of the spherical top side of the supporting section.

Another aspect concerns the distance of the two legs of the retaining element. Preferably, it is provided that the connecting radius between the lower leg and the connecting section is smaller than the connecting radius between the latter and the upper leg. This causes the retaining element to seat itself in the assembled state, i. e. slightly bent open, with its connecting section closely against the front side of the control lever as well as against the spherical top side of the supporting section.

And finally the invention provides for the distance between the lower leg and the upper leg of the retaining element to be greater in the vicinity of the connecting section than in the area of the free end of the two legs. This has the effect that, given selection of a suitable, preferably sheet-metal material for the retaining element, the control lever and the support lever are held together in the assembled state by an increased elastic retention force.

## Brief Description of the Drawings

The invention is explained in more detail in reference to the attached drawings of an embodiment. The drawings show:

Figure 1 a schematic lateral view of a cam follower,
Figure 2 a top view of the cam follower, according to Figure 1,
Figure 3 a cross-sectional view A-A, according to Figure 2,

Figure 4 a perspective view of a retaining element for connection of a cam follower with a support element,
Figure 5 a side view of the retaining element in accordance with Figure 4,
Figure 6 a top view of the top side of the retaining element in accordance with Figure 4, and
Figure 7 a top view of the bottom side of the retaining element in accordance with Figure 4.

## Detailed Description of the Drawings

Figures 1 to 3 show a control lever, designed as a cam follower 1, of a mechanical valve controller of an internal combustion engine, which is, in essence, known and which was described above. This cam follower 1 is pivotable around an axis of rotation 2 and exhibits a supporting section 3, in which a spherical top side 4 of a calotte-shaped recess 5 is provided between two wall sections of the cam follower 1.

As can be gathered, in particular, from the cross section A-A through the cam follower 1 in Figure 3, the calotte-shaped recess 5 receives a support element 6 for the cam follower 1, which support element is designed, in this case, as an axially movable piston of a piston-cylinder configuration, which is not shown in detail.

The support element 6 exhibits a spherically shaped top side 7, which fits precisely into the calotte-shaped recess 5 of the cam follower 1. Below this top side 7, there is an undercut 8 in the support element 6, with said undercut serving to receive the retaining element 9 shown in Figure 4.

This retaining element 9 is designed, in this case, as a sheet-metal component and is provided with an upper leg 10 as well as a lower leg 11, which are connected to each other via a connecting section 12.

As illustrated by the perspective view of the retaining element 9 in accordance with Fig. 4, geometrically closed openings are provided in the two legs 10, 11. Their function is explained in reference to Figures 5 to 7.

What is important is that the opening in the upper leg 10 is essentially circular and the opening in the lower leg 11 is essentially slot-shaped. It is also revealed that the material ridges on both sides of the elongated opening in the lower leg 11 engage into the undercut 8 of the support element 6, while the circular opening in the upper leg 10 is supported by the spherical top side 4 of the cam follower 1.

As shown especially in Figure 5, the retaining element 9 consists of a bent and smooth-surfaced sheet metal, with a connecting section 12 connecting a top leg 10 and a bottom leg 11. As can be easily gathered from this figure, the retaining element 9 is shaped from a flat sheet metal piece such that the bending or connecting radius between the lower leg 11 and the connecting section 12 is smaller than the bending radius or connecting radius between the connecting section 12 and the upper leg 10. In the assembled state, this has the effect, on the one hand, that the retaining element 9 is seated closely against the cam follower 1, and on the other hand, it serves to make sure that the connecting section 12 bends forward to produce an increased bear-on pre-tension in the direction of the spherical top side 4 of the cam follower.

Figure 5 also discloses that the retaining element 9 is shaped such that the distance L2 between the upper leg 10 and the lower leg 11 in the area of the connecting section 12 is greater than the distance L1 in the area of the free ends 15, 16 of these legs. This non-parallel orientation of the two legs 10, 11 has the effect of a further increased mechanical pre-tension of the retaining element 9 for the connection of cam follower 1 and support element 6.

Figure 5 also shows that the free ends 15, 16 of the two legs 10, 11 point away from each other, which facilitates the assembly of this retaining element for the pivotable and captive connection of a control lever 1 with the support element 6.

As can be gathered especially from Figures 6 and 7, the receiving openings in the two legs 10, 11 of the retaining element 9 exhibit different diameters and geometries, with the two openings, however, not being bifurcated, but having a geometrically closed design. Thus the opening 13 in the upper leg 10 has an essentially circular geometry, which has the effect that the spherically shaped top side 4 of the supporting section 3 of the cam follower 1 is securely received in this position or the retaining element 9 can be securely supported in this position.

In contrast, opening 14 in the lower leg 11 is essentially slot-shaped and has, in the embodiment presented here, a stadium-like design, with two essentially parallel opening sections being connected via two semi-circular opening sections. As shown in Figure 7, the semi-circular opening sections are provided with additional slot-type extensions 21, 22, which ensure that the support element 6 is easily put over and this lower leg 11 is effortlessly clipped into its undercut 8.

It is also revealed that there are lead-in chamfers 17, 18, 19, 20 provided on the free ends 15, 16 of the two legs 10, 11, allowing easy insertion of the retaining element 9 between the side walls of cam follower 1, with these side walls being particularly readily identifiable in Figure 3.

As shown in Figure 6, the diameter D1 of the opening 13 in the upper leg 10 was selected such that it is greater than the width of the opening D2 in the lower leg 11 at a right angle to its longitudinal extension. This combination has the effect that, given a preset undercut depth, a sufficient retention on the spherical top side of the cam follower is achieved, or that, given a preset diameter of this opening 13 on the top side of the cam follower 1, a sufficiently large undercut depth is utilizable.

And finally Figures 5 to 7 show that the upper leg 10 is axially shorter than the lower leg 11. This has the advantageous effect of a weight and cost reduction as compared to legs of equal length, while the secure retention on the spherical top side 4 of the supporting section 3 of the cam follower 6 is ensured even if the retaining element 9 does not precisely envelop, with the opening 13 of its upper leg 10, the pole area of the spherical top side 4 of the supporting section 3 or if it does not have an approximated spherical shape.

Furthermore, the slightly longer design of the lower leg 11 makes possible a comparatively long slot-shaped opening 14, promoting the centering of the retaining element 6 and the cam follower 1.

**List of Reference Numbers**

| | |
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| 1 | Cam follower |
| 2 | Axis of rotation |
| 3 | Supporting section |
| 4 | Spherical top side |
| 5 | Calotte-shaped recess |
| 6 | Support element |
| 7 | Spherical end of the support element |
| 8 | Undercut |
| 9 | Retaining element |
| 10 | Upper leg |
| 11 | Lower leg |
| 12 | Connecting section |
| 13 | Opening, top |
| 14 | Opening, bottom |
| 15 | Free end of the upper leg |
| 16 | Free end of the lower leg |
| 17 | Lead-in chamfer |
| 18 | Lead-in chamfer |
| 19 | Lead-in chamfer |
| 20 | Lead-in chamfer |
| 21 | Slot-type extension |
| 22 | Slot-type extension |

| | |
|---|---|
| D1 | Diameter of the upper opening |
| D2 | Width of opening in the lower leg at a right angle to its longitudinal extension |
| L1 | Distance near the free end of the leg |
| L2 | Distance near the connecting section |